Cement MILL SECTION of

Concrete

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Glens Falls Company Completes Office and Laboratory Building

The new building recently completed by the Glens Falls Portland Cement Co. and now used for office and laboratory purposes, represents what is considered the last word in construction and arrangement of such facilities for a cement company. The building is two stories high, the lower story being constructed of monolithic concrete, with rubbed finish on the interior, and the upper story of three-coat "spatter dash" stucco on hollow tile. The roof is concrete with Barrett surface. The upper office floors are of concrete on expanded metal, surfaced with ½-in. magnesite flooring, and the lower office floors have the same surfacing on solid concrete. The upper corridor floors are of translucent glass with terrazzo border, and the lower corridor floors of plain concrete.

The interior wood finish of the offices is mahogany, which blends well in color with the office walls and ceilings, stippled in buff. All piping and conduits, except for hot water and steam, are concealed, being embedded in the concrete and leaving maximum amount of clear wall space.

In the laboratories the walls are finished with white laboratory enamel, and all the woodwork is finished in white enamel down to the bench tops. Below the bench tops the finish is natural wood color, varnished.

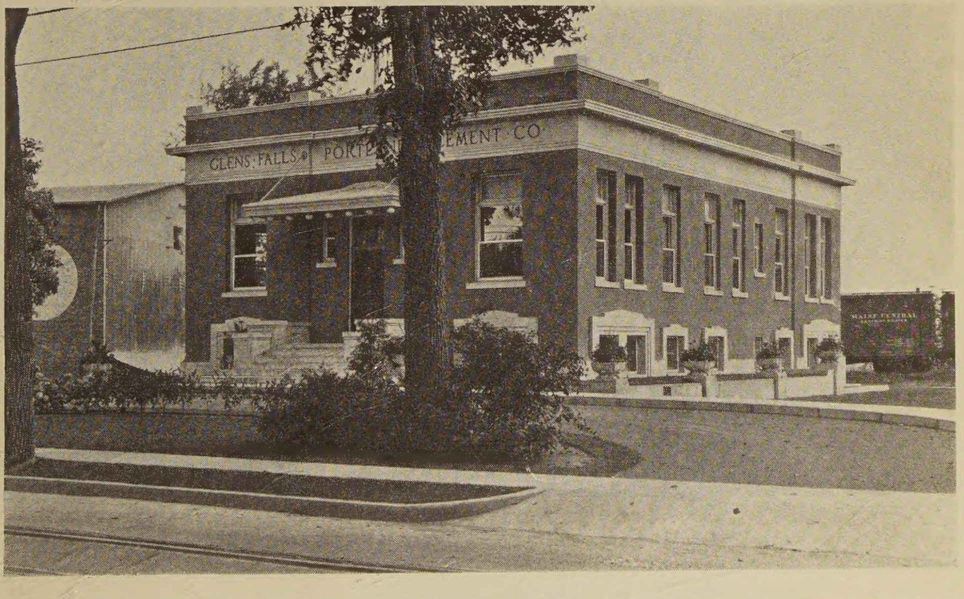
All laboratory benches are fitted with water, gas, pressure and suction.

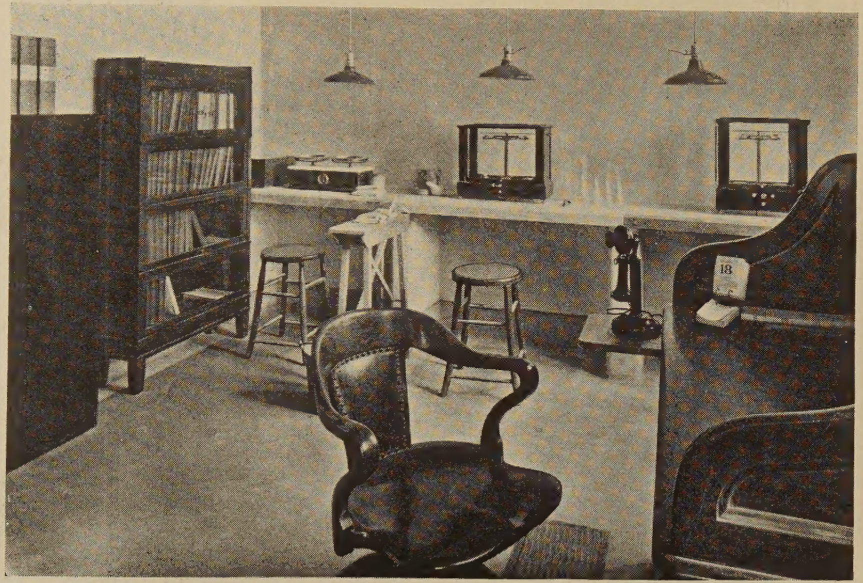
The hood floor is of red clay tile on a concrete slab, carried by two steel channels. All gas and air connections are brought forward under the hood floor to the front header and taps, and rubber connections are made to burners through a 1-in. 45° slot, just back of the sash, to obviate the necessity of reaching over the work. Separate flues are provided in the walls for the hood and boiling test apparatus.

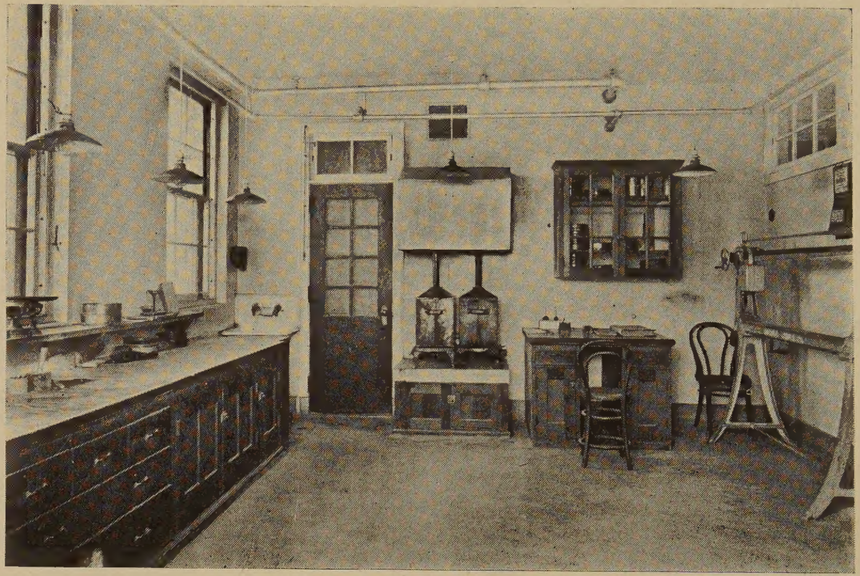
The lower or laboratory floor is divided into 11 rooms or sections, as illustrated in the accompanying plan (Fig. 2). These various rooms include supply room for stationery; briquette tanks and wash room; stairway; lavoratories; laboratory for physical testing; laboratory for chemical testing; balance room and office; furnace room; fuel room; record vault and corridor, with glass ceiling. An enclosed glass shed for mechanical sieving is placed outside and detached from the main laboratories to confine the noise and dust.

In the furnace room are a motor and blower for air

FIG. 1—NEW BUILDING ERECTED BY THE GLENS FALLS PORTLAND CEMENT CO., FOR OFFICES AND LABORATORIES







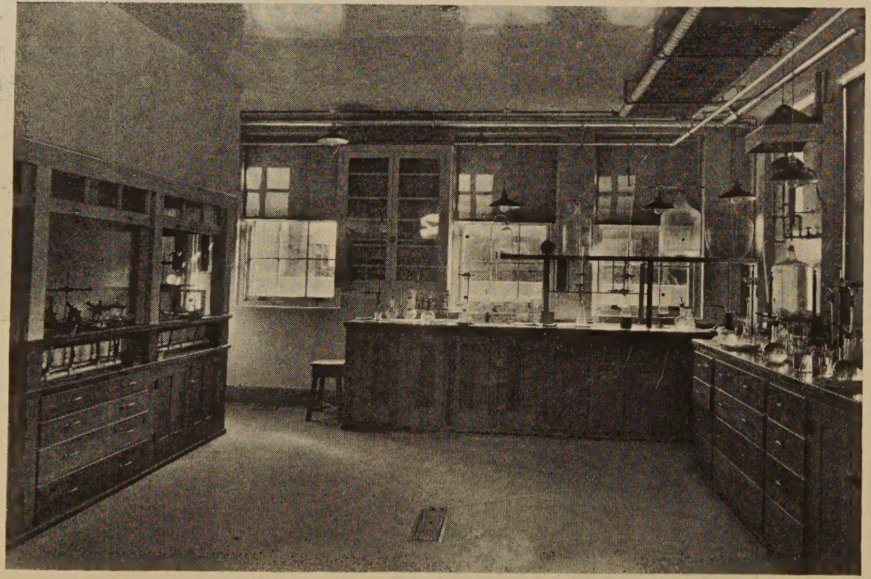


Fig. 3—(Upper Left) Balance Room and Office, with Marble Balance Shelf

Fig. 4—(Lower Left) Laboratory for Chemical Testing, Showing Hood in Left Foreground

Fig. 5—Laboratory for Physical Testing—Briquette Testing Machine on the Right

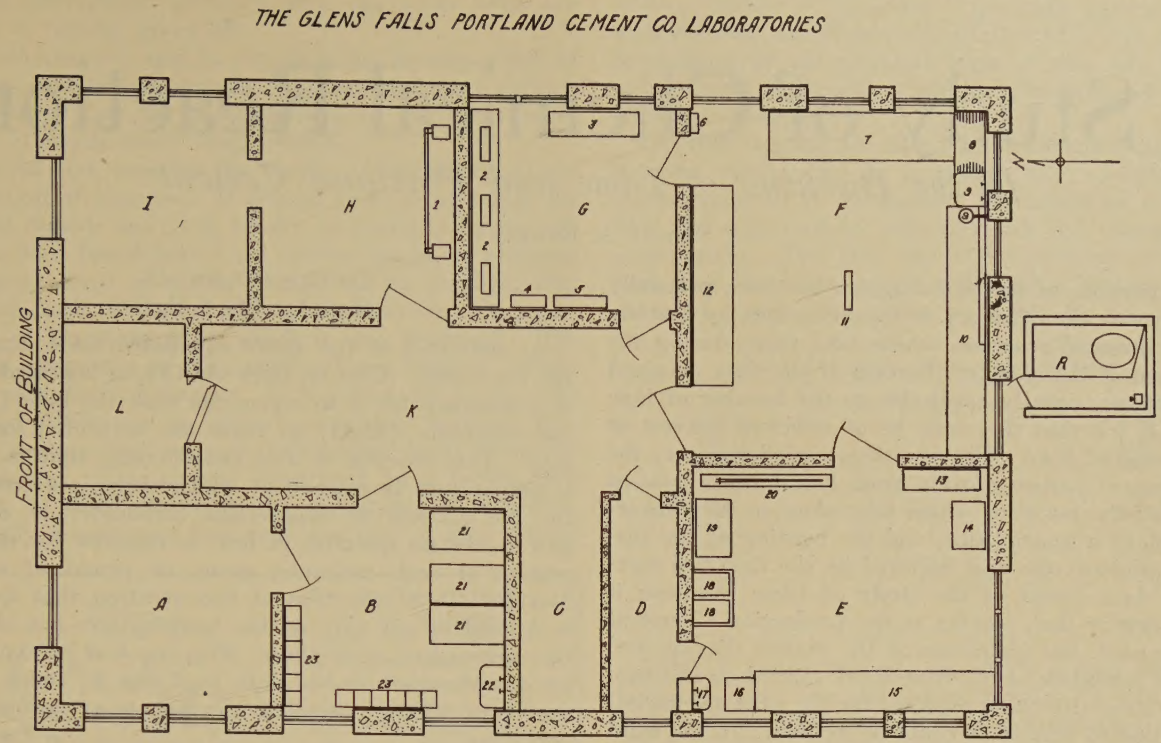


Fig. 2—Plan of Lower Floor, Showing Layout of Laboratories

pressure and suction, operated by a control switch in the laboratory for chemical testing.

The balance and office room contains a marble shelf supported on concrete piers extending below foundation, as shown in Fig. 3. A desk, bookcase and filing case are conveniently arranged, and their relation with respect to the windows insures good light.

The laboratory for chemical testing, shown in Fig. 4, is large, providing ample space for the bench for volumetric analysis, the drain board, porcelain sink and distilled water apparatus, bench for gravimetric analysis and hood. Service taps in the floor box are provided for use in connection with a new work bench when such is required.

The next largest room is the laboratory for physical testing, in which are arranged the slate moist closet, sample racks for shipment samples, glass top bench for physical testing, waste box and sink, boiling test apparatus, briquette testing machine, and desk. These are all conveniently arranged with respect to each other, and with respect to the windows, so as to make the most possible use of the light.

In the room designated as wash room, three tiers of briquette tanks are arranged with two tanks in a tier. Other equipment includes a sink and two rows of lockers for laboratory operatives.

All of the laboratory equipment is up to date and has been selected so as to enable experimental work and research in the manufacture and testing of cement as well as the regular routine work necessary for laboratory control of the finished product.

Construction work in connection with the new building was carried out under the direction of the company's officials, and most of the construction work was done by employees of the company. George F. Bayle, Glens Falls, is president of the company; George F. Bayle, Jr., is vice-president, and John B. Dixon, chief chemist.

Record of Accidents in Quarries

Accidents at stone quarries throughout the United States in 1921 resulted in the death of 100 employees and the injury of 10,465 others, according to figures compiled by the Federal Bureau of Mines.

The average number of men employed in quarries was 77,185, who worked a total of 17,987,547 shifts, an average of 233 work days per man. Based upon a standard year of 300 days, the reports show a fatality rate of 2.00 per thousand employees and an injury rate of 174.55. For 1920, the corresponding rates were 2.31 killed and 145.51 injured.

Accidents during 1921 were distributed as follows, according to kinds of stone quarried: Cement rock, 20 killed and 2,233 injured; granite, 18 killed and 940 injured; limestone, 58 killed and 5,248 injured; marble, 6 killed and 406 injured; sandstone and bluestone, 3 killed and 374 injured; slate, 4 killed and 385 injured; traprock, 11 killed and 879 injured.

The principal stone-producing states, the number of persons employed and the number of accidents in each were: Pennsylvania, 14,994 employees, 1,914 accidents; Ohio, 4,570 employees, 726 accidents; Indiana, 4,434 employees, 602 accidents; New York, 4,357 employees, 827 accidents; Vermont, 4,130 employees, 361 accidents; California, 3,719 employees, 684 accidents; Illinois, 3,241 employees, 515 accidents; and Missouri, 3,079 employees, 415 accidents.

Most of the accidents inside the quarries were caused by handling rock at face, flying objects, falls or slides of rock, haulage, and machinery. At the outside rock-dressing plants and crushers, the main causes of accidents were flying objects, machinery, falling objects, hand tools, and falls of persons.

A Study of Chemical Reactions

In the Burning of Lime and Portland Cement

By G. A. Rankin

The purpose of this investigation has been primarily to determine the efficiency of a cement kiln by a study of the chemical reactions which take place during the formation of the clinker. Certain of the data obtained are, however, equally applicable to the burning of lime and it is felt that they may be of sufficient interest to be considered here. The reactions considered are: the liberation of carbon dioxide from limestone or cement raw mix; the reactions which take place in the clinkering zone of a cement kiln; and the burning of the fuel which produces the heat required by the first two reactions. As a result of the study of these reactions it would appear that, insofar as the production of cement is concerned, the liberation of the carbon dioxide and and the formation of the clinker are carried on at temperature as nearly those required for the most economical production of cement as could be desired. In the third reaction considered, the burning of the fuel, however, there is undoubtedly a considerable waste of fuel in maintaining the temperature required in the kiln.

The data of interest in connection with the burning of lime was obtained in connection with the experiments on the liberation of carbon dioxide from limestone and cement raw mix. It was found that the physical structure of lime particles produced varies with varying conditions of burning. It is felt that possibly these physical variations in lime may assist in accounting for the different properties which different limes possess, and in the production of lime with the particular properties required for any special purpose.

In presenting this study, the three series of reactions are considered separately and in the following order: (1) the driving off of the carbon dioxide; (2) the formation of the clinker, and (3) the burning of the fuel. The aim in each case has been to first determine the efficiency of the reactions as they take place in a modern rotary cement mill, in which the raw mix consists of dry cement rock and limestone and the fuel is powdered coal, and then to consider the possibility of increasing this efficiency. In the case of reactions (1) and (2) this involved a chemical and microscopical study of samples taken throughout the length of a commercial kiln and laboratory experiments to determine the rate at which these reactions proceed under varying conditions of time and temperature. The discussion given here in regard to reaction (3) is in part based on the work of other investigators and in part on theoretical considerations.

(1) The Liberation of Carbon Dioxide from the Raw Mix

The first chemical reactions which take place in the kiln are the liberation of the carbon dioxide from the calcium and magnesium carbonates, which results in the formation of calcium and magnesium oxides. (1—A small amount of chemically combined water is driven off and any carbonaceous matter is burned shortly after the mix enters the kiln, but these reactions are not considered of sufficient importance to be taken up in this discussion.)

$$CaCO_3 \pm CO_2 + CaO$$
$$MgCO_3 \pm CO_2 + MgO$$

As indicated in the above equations, these reactions are reversible. That is, after the CO_2 is liberated there is a tendency for it to recombine with the lime (CaO) and magnesia (MgO) to form the respective carbonates. This reaction is also endothermic, that is, after a temperature is reached at which there is a tendency for the calcium or magnesium carbonates to decompose, a certain quantity of heat is required for the liberation of each molecule, gram, or pound of carbon dioxide. It is also true of this reaction that its rate is dependent not only on the temperature, but also on the surrounding atmosphere. This can best be explained by consideration of the data in Table 1, which gives the vapor pressure of calcium carbonate at various temperatures.

Table 1

Equilibrium Pressures (in mm. for $CaCO_3$ at Round Temperatures[1]

t°C.	Pressure in mm.	
500	0.11	
700	25.3	
750	68.0	
800	168.0	
850	373.0	
898	560.0	Atmospheric Pressure
900	773.0	
950	1490.0	

It will be noted that at 500° the calcium carbonate has an appreciable vapor pressure. In other words, at this temperature there is a slight tendency for calcium carbonate to decompose and liberate carbon dioxide and if the pressure of the carbonate dioxide surrounding the calcium carbonate is less than this tendency to be liberated, then carbon dioxide will be given off and continue to do so as long as this condition exists or until all the carbon dioxide has been driven off. Thus, if one heated calcium carbonate to 500° C. in a vacuum and continued to pump off the carbon dioxide formed, eventually all the carbon dioxide would be liberated and lime would remain. The same result would be obtained, however, if one passed a current of air containing no carbon dioxide over the heated calcium carbonate. The decomposition of calcium carbonate under these conditions is of course very slow. But if the temperature is increased the vapor pressure increases and consequently the rate at which carbon dioxide is given off. This increase of vapor pressure with increase in temperature is shown in Table 1. When the temperature is raised to 898° C. the vapor pressure is equal to 760 mm. (atmospheric pressure), and the calcium carbonate readily decomposes without the aid of a vacuum or a current of air. It is apparent then that the liberation of carbon dioxide is similar in many respects to the evaporation of water. Everyone knows, of course, that water will evaporate at room temperatures and that the more rapidlythe water vapor is removed from the surface of the water the faster evaporation will take place. When the temperature of water is raised till its vapor pressure equals atmospheric pressure, then the water boils and vapor is rapidly given off.

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[1] The Thermal Dissociation of Calcium Carbonate, by J. Johnston, *Journal Am. Chem. Soc.*, Vol. XXXII, Nov. 8, 1910.)

What has been said in regard to the decomposition of calcium carbonate is equally true for magnesium carbonate, except that the decomposition of the latter takes place at much lower temperatures.

Let us now consider the results of microscopical examination of limestone or cement rock, from which the carbon dioxide has been wholly or partially driven off. It has been found that if the carbon dioxide is liberated at temperatures up to 900° to 950° C. the resulting lime has the same shape and general appearance as the particles of limestone from which it was produced. The optical properties of the particles have, however, undergone very decided change. It is indeed due to the very decided difference in optical properties between lime and limestone that one can differentiate them under the microscope. This is best illustrated by a sketch such as Fig. 1, which represents the appearance of limestone, partially decomposed limestone and lime as they appear under the microscope with polarized light. Limestone particles are rather strongly birefracting and will therefore appear rather brightly illuminated. Lime, on the other hand, is isotropic, so that it will appear dark. Limestone which is partially decomposed will therefore appear in part dark and part light. As shown in the illustration, partially decomposed particles will consist of an outer coating of lime surrounding undecomposed limestone.

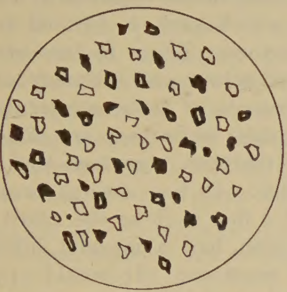

Fig. 1—The Appearance of Limestone, Lime and Partially Decomposed Limestone Under Polarized Light — The Light Particles Represent Limestone, the Dark Ones Lime and Those Partially Dark with Light Centers Represent the Appearance of Partially Decomposed Limestone

In the foregoing it is assumed that the temperature is not over 950° C. If the temperature of burning is much higher, the particles of lime originally formed no longer maintain the original shape of the limestone particles from which they are produced, but break up and form a number of smaller spherical shaped lime particles. This is undoubtedly due to shrinkage of the particles, which takes place at the higher temperatures. Subsequently, if higher temperatures are maintained the small spherical particles of lime gradually increase in size. The various changes which thus take place when a particle of limestone is gradually heated to high temperatures, are graphically illustrated in Fig. 2. The importance of the physical form of lime will be discussed more at length when the formation of cement clinker is considered.

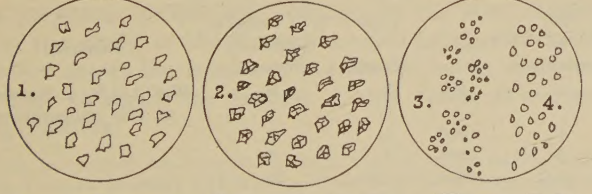

Fig. 2—Diagrams Showing Changes Which Take Place in the Appearance of Lime Particles When Burned at Various Temperatures—1. Lime Burned at Temperature Up to 950° C.; 2. Lime Burned at About 1000°., Showing Shrinkage Cracks Appearing in Particles; 3. Lime Globules First Formed at Temperatures Between 1050° and 1100° C.; 4. Shows Increase in Size of Particles with Increase of Temperature About 1100° C.

In order to study the liberation of carbon dioxide as it actually takes place in a cement kiln, samples were taken every 10 ft. throughout the length of a 125 ft. kiln and subjected to both chemical and microscopical examination. The mix was a dry mixture of cement rock and limestone, which produced a clinker of the chemical composition given in Table 2.

Table 2—Chemcal Analysis of Clinker[2]

Sio_2	20.63
Al_2O_3	6.32
Fe_2O_3	2.89
FeO	0.21
MgO	3.50
CaO	64.12
Na_2O	0.64
K_2O	0.93
TiO_2	0.19
	99.43

Table 3 shows the rate at which carbon dioxide is liberated as the raw mix passes through the kiln. These data were obtained simply by the determination of ignition loss so that the figures given include moisture and carbonaceous matter as well as carbon dioxide. However, these two minor constituents make up such a small percentage of the total ignition loss that for the purpose of the present discussion they may be neglected.

Table 3—Ignition Loss of Samples Taken Every 10 Ft. Throughout the Length Of a 125 Ft. Kiln

	Ig. Loss	Kiln Loss	% Kiln Loss
Raw mix	35.96%	0.00	0.0
15 ft.	34.98	1.38	3.8
25	34.00	1.95	5.4
35	33.41	2.55	7.0
45	31.29	4.67	13.0
55	28.90	7.06	19.6
65	28.54	7.42	20.6
75	23.83	12.13	33.7
85	17.20	18.76	52.1
95	12.70	23.28	64.3
105	0.19	35.77	99.3
115	0.26	35.70	99.1
125	0.57	35.39	98.3

These data confirm the work of Newberry, who carried out a similar test on a 60-ft. kiln and published his results in *Cement and Engineering News*, Vol. XII, No. 5. Both Newberry's data and the results given here show that the carbon dioxide is given off rather slowly and gradually up to a point about two-thirds of the way down the kiln and that beyond this point, as the mix enters the clinkering zone, the remaining carbon dioxide is given off very rapidly. In round numbers about two-thirds of the carbon dioxide is given off while the mix is traveling 80 ft. or two-thirds of the way down the kiln, and the remaining one-third of the carbon dioxide is given off in traveling less than the following 10 ft.

Before discussing these data further, it seems best to first take up for consideration the data obtained by microscopical examination of the samples tested for ignition loss.

MICROSCOPICAL EXAMINATIONS OF SAMPLES TAKEN EVERY 10 FT. THROUGHOUT THE LENGTH OF A 125-FT. KILN (DISTANCES ARE GIVEN IN FEET FROM THE FEED END OF KILN)

Raw Mix—The raw mix shows strongly birefracting cement rock and limestone grains, an occasional grain of quartz and black particles of carbonaceous material.

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[2] Analysis by H. S. Washington, of the Geophysical Laboratory.

15 and 25 ft.—For the first 25 ft. the only noticeable change in the samples taken is a gradual lightening of color, due to the increasing amounts of carbonaceous material which has burned off.

35 ft.—At this point there is no definite microscopical evidence that any carbon dioxide has been driven off. The only difference microscopically between this sample and the raw mix is that the color has changed to a light pink brown, showing that practically all the carbonaceous material has been burned.

45 ft.—This sample shows definite microscopical evidence that carbon dioxide has been liberated. This is shown by the isotropic character of edges of some of the limestone and cement rock particles when subjected to polarized light.

55, 65 and 75 ft.—Examination of each of these samples respectively shows a gradual increase in the percentage of isotropic material (lime) and consequently an increase in the carbon dioxide which has been liberated. All of the particles of cement rock and limestone still retain their original shape.

85 ft.—A large part of the sample taken at this point is still raw mix. No chemical combination has taken place. A few grains of free lime have been formed, showing that the original structure of the cement rock and limestone grains is breaking up, but most of the grains from which the carbon dioxide has been completely driven off have retained their original shape. Some grains show that only part of the carbon dioxide has been driven off, while others have lost no carbon dioxide.

95 ft.—At this point all of the carbon dioxide has been liberated and the chemical reactions which result in the formation of the clinker are nearly completed. The small amount of free lime present is in the form of well developed rounded grains.

The foregoing data bring out a number of interesting points in connection with the liberation of carbon dioxide. The microscopical examinations, as might be expected, corroborate the results of the chemical analysis in showing that only about two-thirds of the carbon dioxide have been driven off after the mix has passed two-thirds of the way down the kiln. In addition to this, the microscopical study brings out a number of points not shown by chemical analysis. In the first place it shows in the case of the kiln examined that most of the lime particles have retained the original form of the limestone and cement rock particles, until they have practically reached the clinkering zone. From this it is evident that the temperature of the mix was probably not much above 950° C. very shortly before it was plunged into the high temperature (1400-1425°) of the clinkering zone. It is also evident therefore that the lime particles were in the best condition for reacting most readily with the silica, alumina, etc., as they enter the clinkering zone, since, as will be pointed out more clearly later on in this paper, the particles of lime which have retained their original structure will react more readily with the other oxides of the mix than globules of lime, formed when this structure is broken up.

(2) THE FORMATION OF THE CLINKER

The chemical reactions which result in the formation of the clinker get under way immediately after the carbon dioxide has been driven from the calcium carbonate in the mix. These reactions, which take place between the various oxides, lime, alumina, silica, ferric oxide, etc., result in the formation of a number of very definite chemical compounds. The chemical composition of the more important compounds, which make up over 90% of the clinker, are given in the following equations:

$$\text{(1)}\quad 5CaO + 3Al_2O_3 = 5CaO.3Al_2O_3$$
$$\text{(2)}\quad 5CaO.3Al_2O_3 + 4CaO = 3\text{—}3CaO.Al_2O_3$$
$$\text{(3)}\quad 2CaO + Fe_2O_3 = 2CaO.Fe_2O_3$$
$$\text{(4)}\quad 2CaO + SiO_2 = 2CaO.Sio_2$$
$$\text{(5)}\quad 2CaO.SiO_2 + CaO = 3CaO.Sio_2$$

These reactions are all exothermic, that is, heat is evolved when the compounds are formed. In the kiln studied it was found that these reactions all proceed with such rapidity (the time from the beginning until they have gone practically to completion being less than ten minutes), that it was not possible to differentiate between the start and finish of the various individual reactions. For that reason careful laboratory studies of the formation of each compound were undertaken in order to determine their relative rates of formation.

The raw mix employed for the preparation of each of these compounds was made up of oxides of especial purity, which were mixed in the proper proportions and heated in electric furnaces in which the temperatures could be accurately controlled.

In the case of all the compounds mentioned, it was found that the ease with which each is formed is dependent on a number of factors. These factors are the temperature, the fineness, structure and intimacy of the reacting oxides and the presence of some accelerator or flux. Of these factors the most important are undoubtedly the temperature, the fineness, structure and intimacy of the reacting oxides. It has always been assumed that the presence of a flux such as the small percentage of alkalis in the mix, had a marked influence in assisting in the clinker reactions. It would appear, however, that this is not necessarily true, particularly in the case of a modern rotary kiln, where the reactions which take place in the formation of the clinker proceed with such rapidity. This statement will be discussed when data which will be presented presently are taken up.

To return to a consideration of various reactions listed, let us take them up in the order given.

(1) and (2) *The formation of Tricalcic Aluminate*—In studying the rate of formation of tricalcic aluminate, samples of mix made up of proper proportions of precipitated calcium carbonate and alumina were intimately mixed and burned under varying conditions of time and temperature. The weight of charge burned was in each case small (about .5 gr.), so as to make it possible to bring the whole charge rapidly to any desired temperature. After each burn the charge was subjected to microscopical examination to determine the nature and percentage of the constituents present.

The results obtained are given in Table 4.

TABLE 4—DATA SHOWING THE RATE OF FORMATION OF TRICALCIC ALUMINATE AT VARIOUS TEMPERATURES

No. of Experiment	Temp. °C.	Time in Hours	% of Tricalcic Aluminate Formed	Remarks
1	900	17.	0	$5CaO.3Al_2O_3$ is formed at at this temperature
2	1000	1.	0	
3	1200	1.	0	
4	1300	.5	10	
5	1350	.25	40	
6	1350	.5	50	
7	1350	2.	60	
8	1350	12.	75	
9	1400	1.5	65	
10	1425	.25	95	
11	1425	.5	80	Charge had previously been heated to 1400 1 hour
12	1450	.5	95	

From the data given in the foregoing table it is apparent that the compound $5CaO.3Al_2O_3$ is readily formed at 1200°, but that the tricalcic aluminate only begins to form at 1300°,and even then with great reluctance. At 1350° chemical combination proceeds a little more rapidly, but even when heated for 12 hours at this temperature only 75% of the possible combination has taken place. At 1425° the reaction proceeds with great rapidity, going almost to completion in 15 minutes. These data show how rapidly the rate of the reaction increases with increase in temperature. Experiment 11 in Table 4 brings out the fact, however, that it is not temperature alone on which the rate of the reaction is dependent. In this experiment a charge of mix was first heated for one-half hour at 1400° and then reheated to 1425°, and as a result only 80% combination took place. The reason for this is apparent if one remembers that lime particles or crystals grow or increase in size at high temperatures. When the charge was held at 1400°, a temperature at which chemical combination does not proceed with rapidity, the free lime particles had an opportunity to increase in size so that when the charge was reheated to 1425° the increased size of the lime particles retarded the rate at which the reaction would ordinarily proceed.

In order to determine the influence of a fluxing material on the rate of the reaction, small percentages of various substances were added to the calcium aluminate mix and heated as before to various temperatures. The results obtained are given in Table 5.

TABLE 5—DATA SHOWING THE INFLUENCE OF VARIOUS FLUXING MATERIALS ON THE RATE OF FORMATION OF TRICALCIC ALUMINATE

No. of Experiment	% of Flux	Temp. °C.	Time in Hours	% of Tricalcic Aluminate Formed
1.......	5% $2CaO.Fe_2O_3$	1350	.5	80
2.......	5% $2CaO.Fe_2O_3$	1400	.5	100
3.......	5% Sod. Aluminate	1350	.5	80
4.......	5% Sod. Aluminate	1400	.5	90
5.......	5% Sod. Silicate	1400	.5	85
6.......	5% Sod. Silicate	1425	.5	99

The data in Table 5 shows that while the addition of certain fluxes has some effect in reducing the temperature at which this reaction proceeds readily, the influence in most cases is not very marked, considering the relatively high percentage of flux added.

(4) *The Formation of Dicalcic Silicate*—In the study of this reaction difficulty was experienced in obtaining a pure silica with a physical structure similar to that of the silica in regular cement mix. Both finely pulverized quartz and precipitated silica were used, but in neither case did it appear that these forms of silica react as readily with lime as the silica of clay, cement rock or shale. The mix of silica and calcium carbonate was prepared, burned and examined in the same manner as in the study of the formation of tricalcic aluminate. Table 6 shows the results of a series of burns and gives the rate at which the dicalcic silicate forms at various temperatures.

TABLE 6—DATA SHOWING THE RATE OF FORMATION OF DICALCIC SILICATE AT VARIOUS TEMPERATURES

	Temp. °C	Time in Hours	Percent Dicalcic Silicate	Remarks
1.	1000	1.0	0	200 Mesh Quartz Used
2.	1100	1.0	5	200 Mesh Quartz Used
3.	1200	1.0	10	200 Mesh Quartz Used
4.	1300	1.0	20	200 Mesh Quartz Used
5.	1300	.5	25	Ppt. Silica Ignited at 1400°C
6.	1400	.25	30	Ppt. Silica Ignited at 1400°C
7.	1400	.5	60	Ppt. Silica Ignited at 1400°C
8.	1400	1.0	80	Ppt. Silica Ignited at 1400°C
9.	1400	.5	85	Silicic Acid. Ig. at 700C
10.	1425	.5	80	Ppt. Silica Ignited at 1400°C
11.	1425	1.0	85	Silicic Acid. Ig. at 700C
12.	1425	.5	99	Silicic Acid. Ig. at 700C

From the foregoing data it is evident that as the formation of dicalcic silicate proceeds at any given temperature its rate decreases. This is undoubtedly due in part to the gradual increase in size of the lime particles, but there is another factor which may be of even greater importance. This factor is concerned with the manner in which the dicalcic silicate is formed by interaction between powdered lime and silica when no melting or fluxing has taken place, as in the experiments outlined in Table 6. Microscopical examination of material burned in these tests showed that the dicalcic silicate particles formed retain the shape of the original silica particles. When the lime starts to react with the silica the outer portion of the silica grain is changed to dicalcic silicate, while the inner core of silica remains unchanged and the physical shape of the grain as a whole remains unchanged. As the time of heating is continued, the lime, by some means, gradually penetrates further and further into the silica grain until it is finally all changed to dicalcic silicate, but its shape is that of the original silica grain. There is no very satisfactory explanation of this phenomenon. It seems not altogether improbable, however, that the lime has an appreciable vapor pressure at the temperature of the experiment, and that the lime vapor penetrates the silica and reacts to form the dicalcic silicate. If this is the explanation, then it seems probable that the affinity of the silica for the lime accelerates the vaporization.

Another point to be considered in connection with the data in Table 6 is the influence of the form of silica used on the ease with which it combines with lime to form dicalcic silicate. It will be noted that when precipitated silica or silicic acid which had been ignited to 1400° C. was used instead of pulverized quartz, the rate of formation of dicalcic silicate increased and that there was a still further increase in the rate of formation of dicalcic silicate when the precipitated silica was ignited at 700° C., instead of 1400° C. This is of course to be expected, since the finer the grains and the more porous the structure of the silica the more readily will it react with the lime. It seems not improbable that a still more reactive silica could be prepared, and beyond a doubt the silica as it occurs in the ordinary cement mix is more reactive than any used in the experiments described. The isolation of a pure silica of the same physical nature as that which occurs in shale or cement rock is, however, a matter of considerable difficulty.

(5) *The Formation of Tricalcic Silicate*—A raw mix was prepared by intimately mixing pure precipitated calcium carbonate and precipitate silica which has been ignited at 700° C. The experiments undertaken to determine the rate of formation were carried out in a manner similar to that already described. Some of the data obtained are given in Table 6.

TABLE 7

No. of Exp.	Temp. °C	Time in Hours	Percent of Tricalcic Silicate Formed
1.	1400	.5	10
2.	1500	1.0	50
3.	1540	.5	70

The foregoing data give some idea of the rather slow rate of formation of pure tricalcic silicate at even high temperatures, considerable above these experienced in a cement kiln. The factors which influence the formation of this compound are of course of the same general nature as those which were discussed in connection with the formation of dicalcic silicate. The reason why it is so much more difficult to form the tricalcic silicate is undoubtedly due to the fact that the affinity of lime for dicalcic silicate is not nearly so great as it is for silica.

It will be remembered that in the formation of tricalcic silicate lime first combines with silica to form dicalcic silicate, and that this compound in turn reacts with more lime to form the tricalcic silicate. In the formation of both of these compounds it has been pointed out that the physical structure of both the lime and silica has a marked influence on the rate of formation, and that the reactivity of the silica used in preparation of the pure compounds was probably not as great as the silica present in the commercial cement mix. This is brought out rather clearly by laboratory experiments with a commercial mix.

Laboratory Studies of the Rate of Formation of Commercial Clinker

In the laboratory studies of the formation of commercial clinker the experiments were carried out in the same manner as for study of the formation of each of the individual pure compounds. The mix used was that obtained from a mill using cement rock and limestone, the composition of whose clinker is given in Table 2. Data are given in Table 8 showing the percentage of chemical combination in the mix when maintained at various temperatures.

Table 8

Data Showing the Chemicaal Combination in a Commercial Mix at Various Temperatures

Temp. °C	Time in Hours	Percentage Combination	Remarks
1000	1.00	0	
1100	1.0	10	No fusion
1200	1.0	25	No fusion
1250	1.0	50	No fusion
1300	1.0	75	Fusion Started
1325	1.0	90	
1375	1.0	98	
1400	.5	99	
1425	.25	99	

The data in the above table show conclusively that the intimacy of contact and physical structure of the lime, alumina, silica, etc., in a commercial mix is such that these oxides react much more readily than when these same oxides have been isolated, purified, mixed in the proper proportions and burned to form the various compounds present in cement clinker. Thus in the burn of a commercial mix at 1250° C., a temperature at which there is no fusion, is sufficient for 50% of the mix to combine as tricalcic aluminate, dicalcic silicate and tricalcic silicate. Whereas, in the studies of the formation of the individual compounds made from pure oxides, it was found that a temperature of 1350° was required for the reaction to go 50% toward completion at the end of one hour, in the case of the tricalcic aluminate and dicalcic silicate, and temperature of 1500° C. was required in the case of tricalcic silicate.

It will also be noted from the data in Table 8 that the commercial mix starts to fuse or melt at a temperature of about 1300° C. As the temperature of burning is increased above 1300° C. the rate of chemical combination is greatly increased, until at a temperature of 1325° C. the reactions go practically to completion in 15 minutes.

It is not fair to assume that the rapid chemical combination which takes place at 1425° C. is due in any very large measure to the partial fusion of the mix which has taken place at the same time. It seems much more probable that the rapidity of the reaction is due in a much larger measure to the physical structure of the oxides in the mix. This point, which has been so continually harped upon in this article, is further strengthened by the fact that when fusion starts the original structure of the oxides of the mix is rapidly broken up, and if they do not immediately combine they increase in size rather rapidly and their reactivity is thus decreased. Thus it may truly be said that the partial fusion of the mix may have a retarding action on the combination of the oxides, as well as an accelerating action due to the mobility it gives those molecules which are actually melted.

The temperature, 1425° C., at which it was found by laboratory experiments that the reactions go practically to completion in 15 minutes, is practically the same as the maximum temperature of the clinker in the kiln studied. It is interesting, therefore, to compare the rapidity of the combination as it actually takes place in the commercial kiln to the results of laboratory experiment. This can best be accomplished by presenting the results of microscopical examination of the mix at various points as it passes through the clinkering zone. Incidentally, the data to be presented in this connection are a continuation of the data already presented in connection with the liberation of carbon dioxide as the mix passed through the kiln. It will be remembered that samples were collected every 10 ft. throughout the length of a kiln shortly after a shutdown, and each sample was submitted to microscopical examination. Starting at a point 85 ft. from the feed end of the kiln, results of the microscopical examination will be given for the remaining samples collected between that point and the discharge end of the kiln.

85 ft.—It will be remembered that at this point microscopical examination of the sample collected showed that no chemical combination had taken place, and that a large part of the mix at this point was still raw mix.

95 ft.—The sample collected at this point shows that the chemical combination is about 90% completed. The particles of the various compounds formed are so exceedingly fine grained that it is not possible to estimate the relative percentage present, except in the case of lime, which is in well formed grains and makes up about 5% of the mix.

105 ft.—At this point the reaction has gone practically to completion, as is evidenced by the fact that there is only a trace of lime present. The particles of crystals of the various compounds formed have increased to about five times their size in the previous sample at 95 ft. Each of the main constituents can be readily identified. The clinker is made up of about 20% dicalcic silicate, 50% tricalcic silicate, 20% tricalcic aluminate, the remaining 10% consisting of dicalcic ferrite, a brownish glass, and other minor constituents too minute to identify. Percentages given are based on estimates made under the microscope, and so are volume rather than weight percentages.

115 ft.-125 ft.—Microscopical examination of the clinker at 115 ft. and at the discharge end of the kiln shows no further change in the constituent of the clinker.

The foregoing data show that chemical combinations which result in the formation of the clinker take place in a very short space of time; it is also evident from the microscopical examination that the temperature of the mix increases very rapidly as it enters the clinkering zone. From a consideration of both plant and laboratory data, it seems probable that the temperature of the mix at a point 85 ft. from the feed end was not over 1000° C., and that in passing through the next 20 ft. the temperature of the mix was raised to about 1425° C. This is undoubtedly due largely to the proximity of the mix at this point to the flame, although it seems not improbable that the exorthermic nature of the chemical reactions play an important part in this sudden increase in temperature.

Briefly summarizing the foregoing data and discussion of the physical changes and chemical reactions which take place in the mix, it has been shown (1) that after the mix has passed two-thirds of the way through the kiln, only about two-thirds of the carbon dioxide has been driven off; that the temperature of mix has slowly increased to about 1000° C., and that the physical structure of the mix has undergone no appreciable change, that is, the shape of the grains of mix have remained unchanged from the time they entered until they have passed 85 ft. through the kiln; (2) that as the mix passes through the following 20 ft., the remaining carbon dioxide is driven off, the chemical reaction has started and gone to completion and the temperature of the mix has increased rather suddenly from 1000° C. to 1425° C.; (3) that the fact that the individual grains of mix maintain their original structure and shape until they are plunged into the high temperatures of the clinkering zone, is in a large measure the reason why the chemical reactions which result in the clinker formation proceed with such rapidity; (4) that the driving off of the carbon dioxide and the formation of the clinker are undoubtedly carried out at the temperatures required for the most economical production of portland cement.

(3) The Burning of the Fuel

The burning of a fuel is a chemical reaction in which oxygen combines with the elements of the fuel, ordinarily carbon and hydrogen, to form carbon dioxide and water. This reaction is accompanied by an evolution of heat and a given quantity of any particular fuel when burned will produce a definite quantity of heat, regardless of the rate at which the reaction takes place. Thus one might take a lump of coal and place it on a fire where it would require an hour or more for it to be completely oxidized, or burned, but the amount of heat evolved would be just the same as if the lump of coal had been finely pulverized, mixed with the theoretical quantity of liquid oxygen required for complete combustion, and exploded with a detonater, in a fraction of a second. The temperature attained by the explosion, however, is much higher than any temperature produced by the slow burning lump of coal. In other words the temperature produced in burning a fuel is in a large measure dependent on the rate of the reaction or rate of burning.

In a cement kiln it is a high temperature rather than simply a large quantity of heat that is desired so that for the most efficient operation of a kiln the reaction between the oxygen of the air and the elements of the fuel should proceed at the maximum rate.

This point has been emphasized in an article by W. H. Klein, "Combustion in Rotary Kilns," which appeared in the October, 1919, issue of Concrete. The conclusions given in this article are as follows:

1. The efficiency of a rotary kiln operation is a direct function of the temperature that can be maintained in the front of a kiln.
2. That the temperature can be increased by the proper selection of fuel, but in the selection of the fuel the heating value alone is not a criterion of its value.
3. To get the highest possible temperature from a given fuel, all the air for combustion should be mixed with the coal prior to ignition, and that should be heated if waste heat can be applied to it.

In this article data are given to show the economy affected by putting these conclusions into practice. It would appear that still further economies might be effected if the rate of the reactions which take place during the burning of the fuel could be still further increased without adding disproportionate increased costs of burning the fuel. That the rate of these reactions can be increased is reasonably certain, but whether or not it is economically feasible is a question. It is, however, a matter which deserves serious consideration.

If one should mix pure oxygen and powdered coal in the proper proportions for complete combustion, one would have a very explosive mixture, and the temperature attained on ignition would be considerably higher than that obtained if a similar mixture employing air instead of oxygen were ignited. This idea of using oxygen in place of air in burning powdered coal in a rotary kiln is not new, but it presents interesting possibilities. The advantages of using oxygen are that it makes possible a higher flame temperature, with a lower consumption of fuel, and that it reduces by about 60% by weight the gases passing through the kiln. This in itself should account for a big saving in that it would reduce by about 60% the amount of heat which is now carried up the stack, granting, of course, that the temperature of the flue gases was not increased by the use of oxygen. It would, however, appear that the temperature of the flue gases would be considerably reduced by the use of oxygen. Before considering the use of oxygen it would of course be necessary to determine whether the cost of oxygen used would be materially less than the saving in coal. It would also be necessary to devise a special type of burner, such that there would be no danger from disastrous explosions, and one in which the speed of the oxygen-coal mixture as it leaves the burner should be considerably greater than its rate of explosion.

Conclusions

1. It has been shown that in the burning of portland cement the reactions which result in the liberation of the carbon dioxide and those resulting in the formation of the clinker are carried out at temperatures as near those required for the most economical production of cement as could be desired. It has also been found that the lime of the limestone and cement rock when it enters the clinkering zone is in its most chemically reactive form.

2. The reactions which take place when the fuel is burned to produce the heat in the kiln do not appear to be carried out in an efficient or economical manner. The suggestions offered in the paper written by W. H. Klein, which has been referred to, seem to offer big possibilities in the matter of fuel economy. It would also appear that the utilization of oxygen in burning the fuel offers possibilities in that it eliminates the great volume of nitrogen which has to be heated up as it enters the kiln and carries heat or when it leaves and performs no useful service. The nitrogen being an inert gas, which makes up 80% of the air.

3. In connection with the study of the liberation of carbon dioxide from the mix, it was discovered by microscopical examination that the physical form of the lime varies depending upon the temperature. If the lime is burned at temperatures of 950° C., or below, the particles of lime retain the original shape of the limestone. The particles are thus somewhat porous, voids being present in the space formerly occupied by the carbon dioxide. As the temperature of burning is increased to about 950° C., this porous structure is broken up into minute spherical globules of lime. With continued heating, these particles increase in size depending upon the time and temperature of heating.

A Rapid Volumetric Method

For the Determination of Magnesia in Carbonate Rocks

H. R. BRANDENBURG
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COWELL, CAL.

The following rapid volumetric method for the determination of magnesia in carbonate rock has been worked out in the laboratories of a cement company, and after extended tests has proven itself to be accurate within the limits that could possibly be imposed for a volumetric magnesium method. It is believed by the authors to be the only volumetric method known, combining speed and accuracy and as such, should commend itself to the profession.

Acid: Prepare a 2/5N HCL solution, containing 2 cc of a 1% alcohol Phenolphtalein solution, as indicator per liter.

Alkali: Prepare a 2/5 N NaOH solution.

STANDARDIZATION

Measure into a 300 cc Erlenmeyer flask 50 cc. of the acid solution, provide a water cooled condenser suspended in a vertical position, secure the flask to the condenser by means of a perforated and tightly fitting stopper, place busen burner under flask and heat to boiling. Remove and while still hot titrate with the alkali, dilute or strengthen, until 50 cc of the acid is neutralized by exactly 50 c. c. of the alkali.

Now weigh out 3 portions of .75 gram each of c. p. calcium carbonate (previously passed thru 80 mesh and standardized for purity by gravimetric methods) into 3 Erlenmeyer flasks adding to each 50 c. c. of the acid, boil on the reflux condenser until solution of the carbonate is complete and all CO_2 has been expelled; now titrate back with the alkali as above directed. Let us assume the purity of the calcium carbonate was found to be 99.56% $CaCO_3$, then .75 gr. of material equal .7467 gr. $CaCO_3$; in titrating back we consumed 12.8 c. c. alkali, hence the acid consumption was 50—12.8= 37.2 c. c. acid. By now dividing .7467 by 37.2 x 100 we obtain a factor of 2.012, i. e. using a ONE gram sample for the determination, each c. c. of acid equals—

2.012 % $CaCO_3$
1.688 % $MgCO_3$
.804 % MgO

As thus far described we have the regulation method of estimating $CaCO_3$ in limestones, and the results so obtained will be accurate in the absence of appreciable quantities of acid insoluble calcium-silicates or magnesium carbonates.

If, however, we have magnesia present in appreciable amounts and must ascertain its percentage, and to obtain the correct percentage of calcium carbonate, we must proceed as follows:

MAGNESIA DETERMINATION

A. Weigh 1.0 gr. of the finely powdered, rock sample into a 300 c. c. Erlenmeyer flask and add 60 c. c. of the acid (50 c. c. might suffice, but in presence of large amounts of magnesia 60 c. c. will assure us of a more thorough decomposition) boil on condenser as previously directed, but instead of titrating the excess acid back with NaOH in a hot solution, be sure to cool the solution before titration, titrate rapidly, yet carefully, to the *first pink only* and record the number of c. c. so used as *A*.

B. Place flask on condenser again and heat *just* to boiling, have ready 1.5 grams of solid c. p. sodium oxalate and add same to the solution in the flask, boil for a minute or two, remove from flame and add to the solution a decided and measured excess of the alkali solution, record the number of c. c. NaOH so used as *B*.

C. Boil with the excess sodium hydrate for two or three minutes on condenser, remove from flame, cool under tap, transfer contents to a 200 c. c. graduate, fill to the mark with water and shake thoroughly, filter through a double fluted paper into a 100 c. c. graduate discarding first and probably turbid runnings, filter off 100 c. c. transfer to a clean Erlenmeyer and titrate carefully back with the alkali until the pink color is just discharged, note the number of c. c. NaOH, double the reading (for 200 original vol.) and record as *C*.

CALCULATIONS OF RESULTS

Employed: 1.0 gr. rock-sample, Original number c. c. Acid (60)=O.

$A=$ 9.85 c. c.
$B=$40.00 c. c.
$C=$31.70 c. c.
$O=$60.00 c. c.

$$(B—C) \text{ x factor} \begin{cases} 1.688—MgCO_3 \\ .804—MgO \end{cases}$$

$$O—(A+B—C) \text{ x factor, } 2.012=CaCO_3$$

EXAMPLE

$$40—31.7=8.3 \text{ x } .804=6.67\% \text{ MgO}$$
$$60—(9.85+40—31.7=41.85 \text{ x } 2.012=83.30\% \text{ CaCO}_3$$

TABLE SHOWING COMPARATIVE ACCURACY

Sample	% MgO				
	Gravimetric	Volumetric			
1	14.57	14.23	14.30	14.68	.....
2	6.90	6.92	7.12	6.88	6.96
3	5.57	5.38	5.22	5.44	5.34
4	2.20	2.33	2.40	.....	.....
5	1.47	1.44	.....	1.33	1.27
6	.65	.64	.58	.....	.....
7	.24	.20	.32	.29	.....

The excess NaOH used per determination varied from 10 to 25 c. c.

Note—A. The titration should *not* be continued after the first pink tinge is reached, though it will fade, additional alkali added will be consumed for magnesium-hydroxide precipitation.

B. The object of the oxalate addition to the neutral solution is to effect a complete precipitation of the lime, the CaC_2O_4 is inactive to NaOH and thus remedies a defect of the older methods, namely, the eventual precipitation of $Ca(OH)_2$ by excess NaOH and its consumption with consequent erroneous results.

Should Magnesia precipitate during the oxalate treatment, which it may, it does not affect the ultimate results as with the excess NaOH, a conversion to the hydrate will be effected just the same. This method will be found valuable for the estimation of Magnesia in dolomitic limestones as in quarry and cement plant control where accurate yet speedy methods are essential and where the magnesia content must be kept within definate limits.

Australian Record

A report from Lithgow, New South Wales, states that the biggest blast of its kind ever made in the cement industry of Australia took place at the Kandos Cement Co.'s quarry on July 8, when nearly 30,000 tons of limestone were removed from a 160 ft. face. To prepare the blast compressed air drills had been at work for three months. One hole was 160 ft. deep and five others ranged from 80 ft. to 90 ft.—*Auckland Weekly News.*

Kansas Cement Companies Fined

The action of the State of Kansas against seven cement companies operating in that state, which was begun in the Supreme Court of Kansas in 1919, ended in the enjoining of the companies named against restraint of trade, and the payment of $25,000 in judgment. The companies named were: The Ash Grove Lime and Portland Cement Co., the Bonner Portland Cement Co., Fredonia Portland Cement Co., Great Western Portland Cement Co., Lehigh Portland Cement Co., Monarch Cement Co., and the Western States Portland Cement Co.

The original petition charged that the defendants had formed and were conducting an agreement in restraint of trade by fixing prices and terms for the sale of cement at wholesale in the State of Kansas. The attorney general, as plaintiff, moved the court to appoint a commissioner to take testimony and make a report of the facts found and his conclusions of law upon them. Upon petition from the defendants, the court deferred the appointment of the commissioner and made an order requiring the filing of the written interrogatories addressed to the defendants, 189 written interrogatories being filed to bring out information from the defendants relative to the questions involved. Supplemental answers were filed by the defendants on the insistance of the State that the answers were incomplete.

Upon the renewal of the State's motion for the appointment of a commissioner, Z. T. Hazen, of Topeka, Kansas, was appointed, and much evidence was introduced by the State. A willingness to agree upon a judgment was indicated to the State by the defendants, and a stipulation was made between the parties for the entry of a judgment against the defendants, judgment being entered on September 5. The judgment rendered enjoins the defendants from maintaining or carrying out the terms of an agreement with Hiram Norcross, under the name Norcross Audit and Statistical Bureau, for the maintenance of a joint bureau and from making or carrying out any agreement, or fixing prices or terms of the sale of cement at wholesale in the state. A further stipulation provides that the defendants shall within 20 days pay to the state school fund $25,000, and that the defendants shall pay the cost of the action, including an allowance of $4,000 to the commissioner for his services and expenses and the services and expenses of his reporter.

American Cement in India

A Letter from Maxted & Knott, Hull, England

We have read with considerable surprise the article in your September, 1922, Mill Section of CONCRETE, page 97, entitled "American Cement in India," apparently taken from the Department of Commerce Report, which states: "At the other extreme of quality is the native cement produced in India, declared by construction engineers to be an inferior variety of mud, and used only in construction of a temporary character, where durability is sacrificed to cheapness in price."

We have been connected with cement works in India for the past fourteen years, and are able to say that several companies in India produce cement which more than fulfills the requirements of the British Standard Specification. All these works have excellent raw materials, and have cement plants made by the leading cement machinery manufacturers.

One of the clients for whom we have acted, erected a plant in 1914 to produce 800 tons of cement per week. The quality of cement produced was so satisfactory that they duplicated their plant in 1921.

Other plants have since started operations, and more will be started shortly.

We have had a lifelong experience as consulting engineers for cement works, and, from our own experience, are able to say that cement of the highest quality can and is being produced by works in India today.

We have samples from these clients for analysis, and the results of a recent test, made by a leading London cement testing laboratory, are appended.

ANALYSIS OF PORTLAND CEMENT

Received from Messrs. Maxted & Knott, Ltd., on June 24, 1922

	%	
Silica (SiO_2)	20.32	
Insoluble residue (sand and clay)	0.36	
Alumina (Al_2O_3)	6.36	
Ferric oxide (Fe_2O_3)	3.00	
Lime (CaO)	63.44	Value after deduction of that necessary for the formation of calcium sulfate = 62.03%.
Magnesio (MgO)	2.45	
Sulfuric anhydride (SO_3)	2.02	Calculated as calcium sulfate = 3.43%.
Matter volatile at a red heat—		
Carbonic anhydride (CO_2) Water (H_2O)	1.33	
Alkalies—		
Potash (K_2O) Soda (Na_2O) ……and loss	0.72	
	100.00	
Specific gravity	….	

RESULTS OF TESTS ON A SAMPLE OF PORTLAND CEMENT

Received from Messrs. Maxted & Knott, Ltd., on June 24, 1922

TENSILE TESTS

Breaking Strain in Lbs. of Briquettes 1 in. x 1 in. in Section

	— Neat Cement —		—3 Sand, 1 Cement—	
	7 days	28 days	7 days	28 days
	770	875	410	485
	750	795	405	470
	740	795	400	460
	735	790	380	460
	720	790	375	455
	700	785	370	430
Ave., lbs. per sq. in.	735 5/6	805	390	460
Specified	450	789	200	416

PERCENTAGE OF WATER USED IN GAUGING THE BRIQUETTES

Sand briquettes	7½%
Neat briquettes	22½%
Aeration	1 day

FINENESS		Not more than
Residue on 180x180 sieve (32,400 meshes per sq. in.)	7.6%	Spec.14%
Residue on 76x 76 sieve (5,776 meshes per sq. in.)	Trace	Spec. 1%

SETTING TIME

Aeration	1 day
Initial	120 min.
Final	4 hrs. 50 min.
Water used	22½%
Temperature	64° F.

SOUNDNESS TESTS

	Not more than
Le Chatelier—Expansion 0.5 mm. after 1 day's aeration	Spec.10 mm.

The railroad strike has not seriously hampered shipments of cement on the Pacific Coast, since ocean-going vessels carry most of the product to ports.

French Cement Fondu Equaled in United States

By H. H. Blaise.
Chief Chemist, Great Western Portland Cement Co.

The writer is impressed by the evident illusion that American manufacturers are behind the Europeans, especially in the manufacture of cements along the line of the French "Fondu."

I feel called upon to refute any such argument since it has come to my knowledge that cements bearing the same properties as this French cement both physically and chemically have been manufactured in quantity lots in this country. Even though such cement was turned out with the property of becoming load-bearing within twelve or fourteen hours, attaining a neat tensile strength of 500 lbs. per sq. in. within 24 hours and a tensile strength of 450 lbs. per sq. in. in seven days with a mixture of one part cement to 3 parts standard sand, which later on increased to 550 lbs. in 28 days, and even though such a cement was produced, it was rejected by the trade of this country as being far too weird a material to handle. The manufacture of this cement has since been abandoned though vast resources are waiting for development.

Though I doubt it, the chemical side of the American plants may not compare with those of Europe. It appears to me that the average European mill was designed either by chemists or with chemical advice with a view to deliberate chemical control throughout every stage of manufacture, with frequent chances for correction. On the other hand many American plants were constructed by purely mechanical heads who sandwiched the chemical division in where it would stand neatly out of the way. I am pleased to observe however that in the recent plants, designers are weaving chemical control throughout the design of construction. I have in mind several noteworthy instances of such forethought.

Although it is a well known fact, that American portlands have been long superior to European productions, this has been, a great deal, due to the care and common sense exercised by American chemists and operators rather than to having convenient methods for control of quality at hand.

All in all I can see no great cause for worry about the inefficiency or backwardness of our chemical forces. Research work is being carried on hand in hand with the development of concrete design and American engineers may have more than the equal of the "Ciment Fondu" when they ask for it.

The National Exposition of Power and Mechanical Engineering will open at the Grand Central Palace, New York City, on December 7, for one week, except the intervening Sunday, and will clearly demonstrate to the general public that the engineer is a tremendous force in civilization today.

The scope of the exposition includes mechanical machinery and machine tools such as are included in any completely appointed machine shop, and is such that benefit will accrue not only to the engineers of the great cement, ceramic, metallurgical and power generating industries, whose fuel and power problems are severe, but also to the industrial manufacturer whose power costs are a relatively small part of the total cost of manufacturing his product.

Lime Association Extends Activities

At a special convention of the National Lime Association, held in Chicago September 20 and 21, plans were formed for a progressive forward movement in the lime industry, particularly in construction and agricultural line. Uses of lime in chemical industries have experienced a steady advance for several years, and it was with the idea of increasing the demand for construction and agricultural lime in the same proportion that the convention was held. The plans for a material enlargement of the activities of the association in matters of research, study of the properties and uses of lime and lime products were made. The immediate purpose of the convention was the ratifying of plans which had been tentatively agreed to and discussion of details of needs of the lime industry as a whole and in the various districts.

An enlarged budget for educational research and promotional purposes was supported, and the extended activities will include investigational work and the development of new products and the spreading of the knowledge gained by this study and research among those who use or ought to use lime or lime products.

W. R. Phillips, general manager of the National Lime Association, visited the various sections of the country prior to the convention, taking up the details of the proposed plan with various lime manufacturers. Much valuable material bearing on the attitude of lime producers, both members and non-members of the National Lime Association, was obtained by Mr. Phillips on the 10,000 mile trip.

A reorganization of the Association was provided and three districts were created, each to have a district manager, acting under the general manager of the association.

The Eastern division's headquarters will be established in Washington, with the national headquarters. The Central division will have headquarters at Chicago, and the Western division headquarters will be located in some western city, a matter which has yet to be decided.

One of the important developments is the establishing of new laboratories and the enlarging of existing laboratories maintained by the association, to supplement the laboratories at Washington, and to be maintained for the free use of lime consumers in solving their problems in the making and using of lime.

The Atlas Portland Cement Co. on behalf of its mill at Navarre, Pa., has filed a series of complaints with the Interstate Commerce Commission protesting the freight rates charged on cement from its Pennsylvania mill to various intermediate stations in Jersey on the Delaware, Lackawanna & Western Railroad, Lehigh Valley Railroad, Central Railroad of New Jersey and other carriers. The company asked reparation and adjustment of rates.

The Lehigh Portland Cement Co. has filed complaints with the Interstate Commerce Commission declaring that freight rates on cement, in carloads, from Fordwick, Va., to Daytona and St. Augustine, Fla., are unjust and unreasonable, prejudicial against its mill at Fordwick and preferential of competitors. Reparation is asked from carriers named defendant to the complaints. Similar complaints are made with respect to the rates on cement from Chapman, Pa., to Key West, Fla., Cocoanut Grove, Fla., and Andersonville, Ga.; also from West Coplay and Chapman, Pa., to Daytona, Fla.

Portland Cement Output in September

The statistics shown in the following table, prepared under the direction of G. F. Loughlin, of the United States Geological Survey, are based mainly on reports of producers of portland cement but in part on estimates. The use of estimates was made necessary by the lack of returns from three producers.

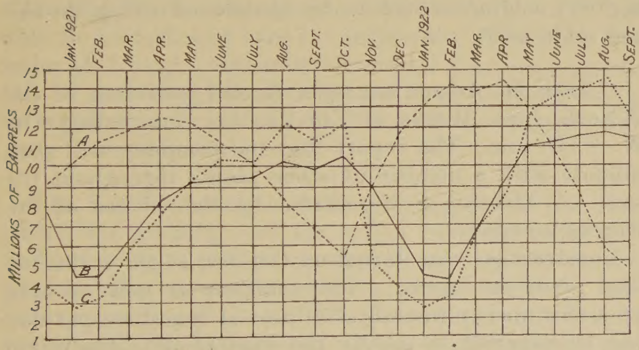
Production, Shipments, and Stocks of Finished Portland Cement in September, 1922, and Preceding Months

Month	Production (bbls.)		Shipments (bbls.)		Stocks at end of month (bbls.)	
	1921	1922	1921	1922	1921	1922
Jan.	4,098,000	*a*4,291,000	2,539,000	*a*2,931,000	10,300,000	*a*13,316,000
Feb.	4,379,000	4,278,000	3,331,000	3,285,000	11,400,000	*a*14,142,000
Mar.	6,763,000	6,685,000	6,221,000	7,002,000	12,000,000	*a*13,848,000
1st quar.	15,240,000	15,254,000	12,091,000	13,218,000	....	....
Apr.	8,651,000	9,243,000	7,919,000	8,592,000	12,600,000	*a*14,470,000
May	9,281,000	11,176,000	9,488,000	12,749,000	12,450,000	*a*12,893,000
June	9,296,000	11,245,000	10,577,000	13,470,000	11,150,000	*a*10,718,000
2d quar.	27,228,000	31,664,000	27,984,000	34,811,000	....	....
July	9,568,000	11,557,000	10,301,000	13,850,000	10,414,000	*a* 8,433,000
Aug.	10,244,000	11,664,000	12,340,000	14,361,000	8,280,000	*a* 5,746,000
Sept.	10,027,000	11,424,000	11,329,000	12,444,000	6,953,000	4,726,000
3d quar.	29,839,000	....	33,970,000	....	....	....
Oct.	10,506,000	....	12,114,000	....	5,348,000	....
Nov.	8,921,000	....	5,195,000	....	9,091,000	....
Dec.	6,559,000	....	3,697,000	....	11,938,000	....
4th quar.	25,986,000	....	21,006,000	....	....	....
	98,293,000	....	95,051,000	....	....	....

a Revised.

Stocks of clinker, or unground cement, at the mills at the end of September amounted to about 2,338,000 barrels compared with 2,766,000 barrels (revised) at the beginning of the month.

Monthly Fluctuations in Production, Shipments, and Stocks of Finished Portland Cement



The Bureau of Foreign and Domestic Commerce, of the Department of Commerce, reports that the imports of hydraulic cement in August amounted to 56,757 barrels, valued at $120,136. The total imports in 1921 amounted to 122,317 barrels, valued at $388,828. The imports in August were, from Sweden, 42,376 barrels; Denmark, 6,116 barrels; Canada, 5,958 barrels; Belgium, 2,061 barrels; Japan, 229 barrels; and Mexico, 17 barrels. The imports were received in the following districts: North Carolina, 42,262 barrels; Porto Rico, 6,116 barrels; Michigan, 3,171 barrels; Washington, 2,757 barrels; San Francisco, 2,175 barrels; Hawaii, 229 barrels; Vermont, 27 barrels; San Antonio, 17 barrels; and Maine and New Hampshire, 3 barrels.

The exports of hydraulic cement in August were 105,156 barrels, valued at $294,737; of this total 102,979 barrels, valued at $281,709 was portland cement, which was sent to Cuba, 48,670 barrels; to the other West Indies, 6,426 barrels; to South America, 26,290 barrels; to Central America, 12,493 barrels; Mexico, 7,814 barrels; Canada, 946 barrels; and to other countries, 340 barrels. The total exports of hydraulic cement in 1921 were 1,181,014 barrels, valued at $4,276,986.

The statistics of imports and exports of hydraulic cement in September are not available.

Imports and Exports of Hydraulic Cement in August, 1922, and Preceding Months*a*

Month	Imports (bbls.)		Exports (bbls.)	
	1921	1922	1921	1922
January	14,678	17,036	225,561	70,725
February	18,269	5,157	84,230	82,421
March	7,631	1,597	97,302	103,556
April	1,540	10,855	93,009	75,412
May	2,035	2,521	82,409	100,068
June	1,657	14,179	100,831	96,263
July	3,455	958	81,091	119,491
August	10,988	56,757	84,538	105,156
September	5,177	(*b*)	84,668	(b)
October	11,448	......	79,871	......
November	20,112	......	71,214	......
December	25,327	......	96,290	......
	122,317	......	1,181,014	......

a Compiled from records of the Bureau of Foreign and Domestic Commerce.

b Imports and exports in September, 1922, are not available.

(A) Stocks of finished portland cement at factories.

(B) Production of finished portland cement.

(C) Shipments of finished portland cement from factories.

Slag Cement

Puzzolan Cement—There is at the present time quite a little general misunderstanding as to what is meant by slag cement, hence the present and existing conditions are of interest. The first slag cement which was manufactured in the U. S. was made at the Illinois Steel Co., near Chicago, under the Whiting patents, and at the Brier Hill Co., near Youngstown, Ohio. Both cements were a mechanical combination of granulated slag and slacked lime. These two ingredients were merely ground together in determined proportions, the resultant product being put in sacks or barrels and shipped to the consumer. This was a cement manufactured of slag but was what is technically known as Puzzolan Cement, a reproduction of the old cement manufactured by the Romans of volvanic ash and slacked lime. This cement made in the U. S. was sold for a time as portland cement, but engineers declined to receive it under this title.

Slag Portland Cement—The Illinois Steel Co. there upon proceeded to make a true portland cement out of slag and limestone, grinding these two raw materials together into a powder, passing the composition or mix through rotary kilns and clinkering the same, thus making a chemical mixture, grinding the clinkers and selling the resultant product in bags or barrels as portland cement.

Iron Portland Cement—In Germany of late years they have been making under the name of Eisen Portland Cement, a cement containing about two-thirds portland cement clinker and one-third granulated slag, mixed together mechanically and ground to the fineness of cement and sold in bags or barrels under the above name. This latter material has not been manufactured in the U. S. nor has it been successful in England, where some attempts were made to introduce it.

Full details as to the amount of Puzzolan cement made in the U. S. and the date when manufacturing ceased will be found in Geological Survey Cement Reports for the last twenty years.

Men and Mills

Notes from the Field

A hearing in reference to the Choctaw Portland Cement Co. was scheduled to be held before the referee on October 30 at McAlester, Okla., and it was expected that the Court would approve an Order of Sale of all the assets. The terms of the sale were to be specified at the hearing.

It was expected that some of the present stockholders would buy the property with the intention of reorganizing and moving the plant to Tulsa, as they had two or three favorable sites at that place as well as an unlimited supply of gas for fuel with a heavy demand in Tulsa County for portland cement for at least the next two or three years. W. D. Ege is trustee.

The Superior Portland Cement Co. is rushing work on its new clinker storage building which is being erected at Concrete, Wash., and which will cost complete, about $150,000. The contract has been awarded to the Rounds-Clist Co. of Seattle, and the engineering work was done by C. L. Wagner, plant superintendent. The building will have a capacity of about 100,000 barrels of clinker and a 20 ton Shepard crane with a Blaw-Knox bucket has been purchased to handle the clinker.

A new two story concrete office building, 25 x 40, is also being erected to cost about $20,000. The Rounds-Clist Co. is handling this contract also.

Dwight P. Robinson & Co., Inc., has been awarded a contract for the construction of the new cement mill at Birmingham, Ala., for the Lehigh Portland Cement Co., of Allentown, Pa. The mill will have a capacity of 1,000,000 bbls. a year.

The Alpena plant of the Huron Portland Cement Co. was in full operation in October and was not compelled to curtail production during the coal shortage. Extensive progress has been noted on the new unit to the plant, but it is reported that it will be some months yet before the addition will be ready for operation.

S. H. Furbush, Jr., has resigned his position in the offices of the Alpena plant of the Huron Portland Cement Co., which position he had held for many years. He is devoting his attention to interests in Alpena.

J. B. Clark, Jr. has recently become associated with the Pennsylvania Crusher Co. as Sales Engineer, and will have charge of the New York office, Hudson Terminal, 50 Church Street, New York City.

Since graduating from the Engineering Department of Penn State, Mr. Clark has had broad experience in plant erection and operation.

William Jennings, superintendent of the Superior Portland Cement Co., Seattle, Washington, is on a trip of inspection through the East.

H. W. Hardinge has returned from a three months trip in Europe, on the "S. S. Berengaria," sailing October 3rd. His trip was for the purpose of studying mining and industrial conditions in Italy, Switzerland, France and England.

Construction in connection with the program being carried out by the Missouri Portland Cement Co. in changing from the dry process to the wet process of cement manufacturing and increasing the capacity of the plant, is progressing rapidly.

The structure for storing cement is being constructed in the form of eight circular reinforced concrete bins, each having an inside diameter of 40 ft. and a height of 70 ft. The methods used in the construction of these silo storage bins, which are rapidly nearing completion, employ sliding forms suspended from vertical steel rods, the forms being raised and the concrete poured at an average height of 9 to 10 ft. in 24 hours.

Other work under way include the new kiln building, with kilns and the necessary conveying equipment.

Thomas McDonald, construction engineer for the Louisville Cement Co., at Speed, Ind., recently fell and received serious injuries. He was making a measurement on top of the storage tanks at the new Brixment plant, standing with one foot on one tank, and the other foot on another tank. He dropped his ruler and made an attempt to catch it. He lost his footing and fell between the tanks, dropping to the concrete base 25 ft. below. He sustained bruises and a very severe fracture of the skull from which recovery appeared doubtful for several hours. While yet in a critical condition, he is gradually improving under the care of Dr. Hauss and trained nurses at the Hauss Sanitarium.

The Cement Securities Co. reports that during the month of September the output of its seven mills was 450,025 barrels, a decrease as compared to August, the reason being lack of railroad cars. Every mill is reported far behind on orders and the present shipments have been running from 100,000 to 125,000 barrels ahead of last year. The two Colorado plants have suffered the most because of the railroad refusing to furnish cars; the coal and fruits getting priority.

The railroad strike is the prime cause of the car shortage, and several big undertakings of the Colorado highway engineers had to be abandoned owing to the lack of cement.

John H. Adams has been elected president of the O'Neals Lime Works at Eureka, Ala., succeeding Dr. W. C. Gewin. The report that the company will consolidate with a number of other plants throughout the state of Alabama is repudiated by the officers of the Eureka company.

Construction was started on October 15 on a 300 ton lime plant at Eureka. The company is now opening up a new quarry whereby 600 tons of limestone per day can be quarried to supply the lime plant. The plant will have 20 upright steel kilns. It is planned to manufacture material rip rap stone, road building stone, raw ground agricultural lime for farmers, as well as bulk lime, cooperage lime and hydrated lime. The building will be of steel and concrete construction, 110 ft. wide and 240 ft. long.

The steamer Mitchell, flagship of the cement carriers of the Huron Portland Cement Co. is again in service, carrying bulk cement out of the Alpena plant to various points on the Great Lakes. The Mitchell was damaged to the extent of $100,000 when she went aground at Detour about two months ago. She was in dry dock at Detroit for several weeks. Captain Booth, formerly of the steamer W. A. Hazard of the cement fleet, has been made captain of the Mitchell.

Frederick Stugard, formerly chief chemist and superintendent of the Kosmos Portland Cement Co., of Louisville, Ky., has accepted a position with the National Cement Co. of Birmingham, Ala., as chief chemist at the plant at Ragland, Ala., manufacturing the "Coosa" brand of Portland cement. The same company also owns the Georgia Cement & Stone Co. of Portland, Georgia. Mr. Stugard was connected with the Kosmos Portland Cement Co. since the day it started production in 1905. He served in the various capacities of assistant chemist, chief chemist, assistant superintendent, and superintendent during the course of his employment at their plant at Kosmosdale, Ky.

The Monarch Cement Co., of Humboldt, Kas., appealed to the public utilities commission on October 19 for relief from the present car shortage. The company declared that unless cars were immediately provided, a large amount of hard surface road work will be held up until 1923. The Monarch company notified the commission it had sixty cars of cement awaiting shipment to road projects.

Carl J. Lofstedt has resigned from the engineering department of the Palmer Bee Co. in Detroit and is now on the engineering staff of the Tidewater Portland Cement Co. of Union Bridge, Md.

Edwin C. Eckel has been called back to active service at the Army Barracks, Washington, D. C. for two months, in order to work out some raw material problems for the General Staff.

The output of the Olympic Portland Cement Co. of Bellingham, Wash., for 1922 probably will be a record one, estimates one of its officials. He places it at between 400,000 and 500,000 barrels. Shipments since January 1, 1922, exceed 400,000 barrels. The company will operate until Christmas.

The Superior Portland Cement Company's plant at Concrete, Wash., will operate until the holidays if it is able to get sufficient cars for shipments. The plant has enjoyed a busy year, and it has used enormous quantities of coal from the Bellingham Coal Mines Colliery, in which President John C. Eden of the cement company is heavily interested.

The Signal Mountain Portland Cement Co. has completed the grading, and the actual construction is well under way as is also the process of opening the quarry. This is being accomplished by the installation of a temporary crushing plant which is furnishing crushed stone for the concrete construction of the buildings and foundations.

At a meeting of the Board of Directors of the Giant Portland Cement Co., Walter L. Haehnlen was elected vice-president, to fill vacancy caused by the death of Charles Scott, Jr.

Notices were recently posted in all departments of the Atlas Portland Cement Co.'s Northampton plant, announcing a general wage increase.

Another shipment of cement, amounting to 20,000 bbls., from Sweden, for construction of the hydro-electric plant at Mountain Island, where the Southern Power Co. is spending $8,000,000, was expected to arrive at Wilmington, N. C., for immediate use.

After almost 25 years in the service of the Atlas Portland Cement Co., at the Northampton plant, as chief engineer until 1915, and since then as plant manager, H. T. Raisbeck, accompanied by Mrs. Raisbeck, sailed on the Sythia for a visit to the old home and relatives in England.

The Kreidersville road house was turned over to the heads of the various departments of the Atlas company, who gathered there shortly after working hours for a dinner given in honor of the plant manager.

On account of the strikes and labor disturbances, the Nebraska Cement Co. stopped burning clinker, with indications that all departments would have to be closed. There has been a big demand for cement, and under ordinary conditions the plant would be in full operation all fall and winter.

With close to a hundred persons in attendance, the annual clambake of the employees of the Penn Allen Cement Co. was held in the grove at the cement plant. The guests of the day were men from New York City and Philadelphia, also other officials of the company.

Trade Publications

Wave Transmission, by Walter Haddon, 132 Salisbury Sq., Fleet St., London, England. A 56 page booklet 5½ in. x 8 in.; illustrated; paper cover. This publication describes a new and sixth method of transmitting power. In wave transmission, wave motions or pulsations are set up in an enclosed column of liquid.

Many practical applications of this method are illustrated including wave transmission to the Haddon rock drill, to riveting or caulking hammer, etc. The application of wave transmission to practical purposes is divided into two main groups: (1)—storage of energy in liquid, (2)—transmission of energy by wave motion.

Porter Fireless Steam Locomotive, by H. K. Porter Co., Pittsburgh, Pa., 8 in. x 11 in., 82 pages, illustrated, paper cover. This new catalog illustrates and describes the Porter fireless steam locomotive, and the principle upon which it operates. The advantages of the Porter fireless steam locomotive are mentioned in part, and directions for operating are included. Engineering data on the subject and typical examples are given to illustrate the use of the catalog tables and data.

Hardinge Conical Ball and Pebble Mills—Catalog No. 7, Section 1, by the Hardinge Co., New York City. This pamphlet is 6 x 9, paper cover, 12 pp. It contains general information dealing with the principles of operation of a conical mill and gives a general description of its uses in the industrial, mining and special fields. It embraces both wet and dry grinding problems and has been revised owing to the large demand for literature on this subject. Copies are now available, and those wishing copies should state in what class of grinding they are interested, in order that they may receive information dealing with their particular class of requirements.

General Catalog No. 400—By the Link-Belt Co. of Chicago, Philadelphia, and Indianapolis. The company announces the completion of a new general catalog embracing their entire line. It is the most complete book it has ever issued on this subject, containing 832 pages, bound in cloth. The catalog not only includes complete Link-Belt line, but also the products of the H. W. Caldwell & Son Co. plant of that company.

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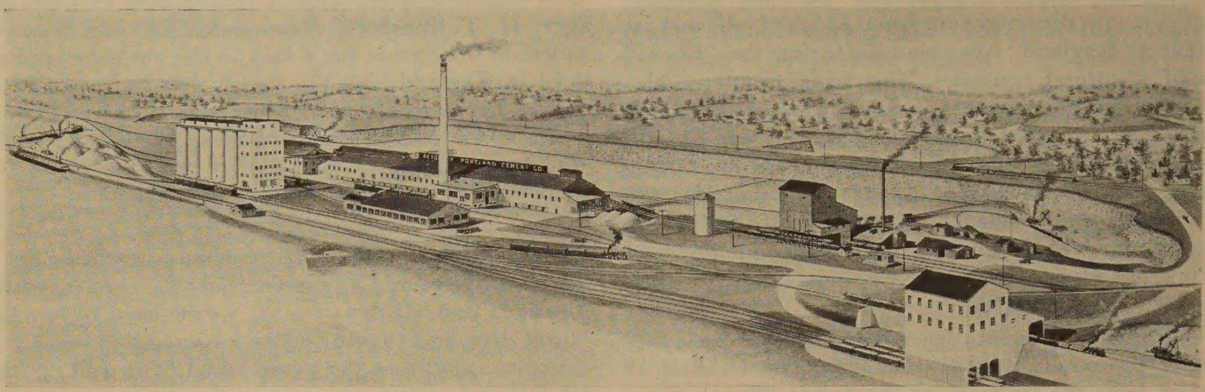
WANTED—Night Superintendent, cement plant in Middle West. State age, experience and salary expected. Address Box 1327, C|o CONCRETE, 1807 E. Grand Blvd., Detroit, Mich.



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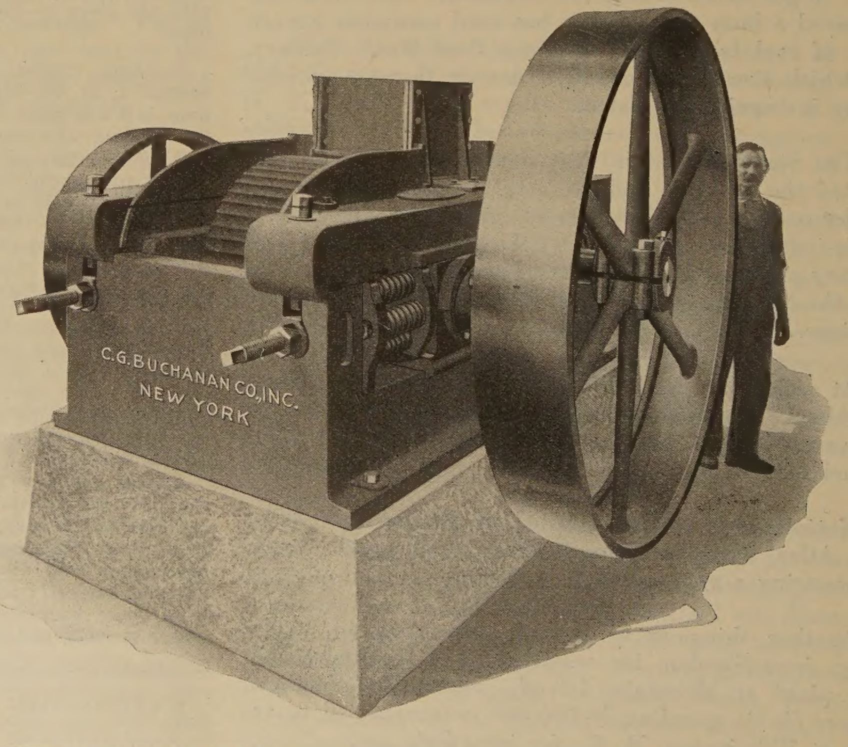

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